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(71) Applicant *(for all designated States except US)*: BICC PUBLIC LIMITED COMPANY [GB/GB]; Devonshire House, Mayfair Place, London W1X 5FH (GB).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: HAIGH, Neil, Richard [GB/GB]; 134 Eastham Rake, Eastham, Wirral, Cheshire L62 9AD (GB).

(74) Agent: DLUGOSZ, Anthony, Charles; BICC Patents & Licensing Dept., Quantum House, Maylands Avenue, Hemel Hempstead, Herts. HP2 4SJ (GB).

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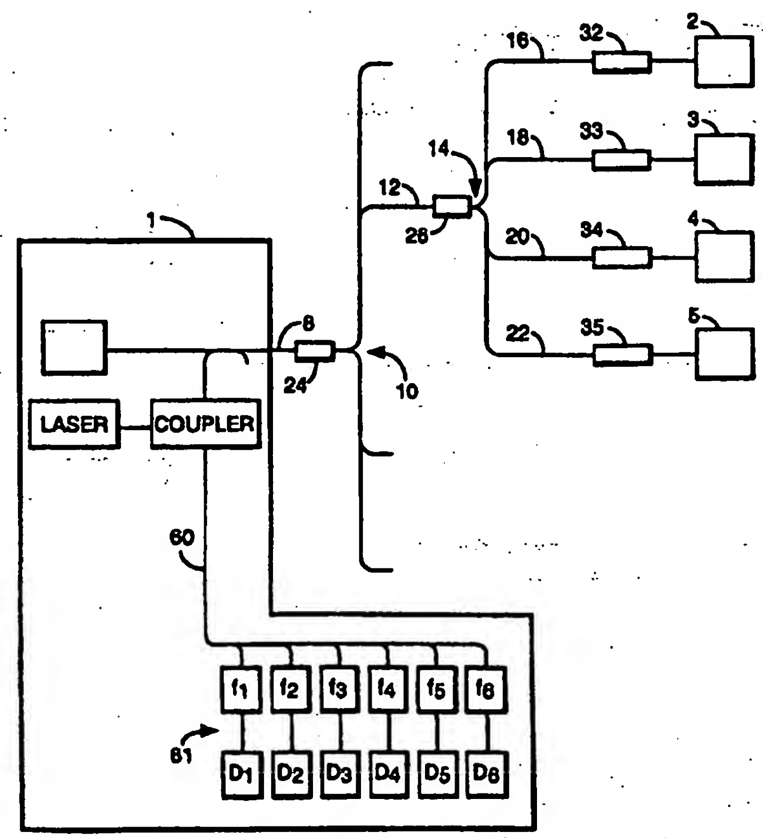
(57) Abstract

An optical fibre system, for example a passive optical network having a tree structure, includes at least one optical fibre and is tested at a number of locations (24, 26 and 32 to 35) by a reflectometry method. The system includes a laser for sending light into the system and a detection station for receiving light that has been reflected at the locations at which the system is tested. The laser emits light at a number of different wavelengths (λ_{42} to λ_{47}) that correspond to different resonant modes of the laser, and each location of the system has at least one Bragg grating (51 to 56) that reflects light at one of the wavelengths of the laser. Different locations in the system have different Bragg gratings and/or combinations of Bragg gratings so that each of the locations will generate a reflection that is characteristic of that location.



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OPTICAL FIBRE SYSTEM

This invention relates to optical fibre systems and to a method of performing tests on them. The invention relates especially to optical fibre networks and to a method of monitoring them to determine fault location therein.

Optical fibre networks are becoming increasingly important in many area of telecommunication technology, and recently many forms of optical fibre networks have been developed for example for telephone systems, cable television, local area networks (LANs) and the like. A network typically may have a tree structure in which a single station end or head end, which may be a CATV receiver, an exchange or a LAN controller, is linked to a number of end users by means of a number of branches in the network. In the case of passive networks, that is to say, networks in which no components need be supplied with power between the station end and the end user, the nodes typically are formed as 1:n splitters for example by fused or planar fibre couplers.

In all such optical networks it is important to be able to monitor the network for breaks in the optical line or degradation of the line, for example due to the presence of moisture. A number of methods have been proposed for monitoring such optical networks based on optical time domain reflectometry (OTDR) and optical frequency domain reflectometry (OFDR). In OTDR a pulse is sent from the station end of the network, and the reflected signals are analysed as a function of time in order to judge the distance between the station end and a break in the optical line. However, since

the pulse will be reflected by the termination of the line at each end user in addition to any reflection that may be caused by a break in the line, a single pulse will cause a large number of reflections to be generated with different time delays, with the result that it may not possible to distinguish a fault in the network from the other reflections. Furthermore, if a fault occurs in one of a number of branches of a network, it is usually not possible to determine in which branch the fault is located. Alternatively, one could test the network by sending a signal from the end users' premises back to the station end, but it is not commercially viable to send a maintenance engineer to each end user's premises for the purpose of routine maintenance. U.K. patent specification No.2,268,652A discloses a method of monitoring a branched optical network by an OTDR or OFDR technique in which, once a fault is located in the network by monitoring at the station end, a signal is introduced into the network at successive nodes along the network in order to home in on the fault. However, such a method still involves the necessity for personnel to travel to a number of locations before the position of the fault can be identified.

It has been proposed to incorporate a Bragg grating at each end user's premises which will reflect light of a wavelength that is characteristic to that subscriber, so that reflections observed when monitoring the network can be assigned to individual end users and faults in the network can therefore be assigned to particular branches. However, such a system has the problem that the number of different wavelengths that can be employed would severely restrict the possible number of end users, and that the number of end users will normally considerably exceed the possible number of different wavelengths that can be employed to monitor the system.

According to one aspect, the present invention provides an optical fibre system which includes at least one optical fibre and which is tested at a number of locations by a reflectometry method, the system including a laser for sending light into the system and a detector system for receiving light that has been reflected at the locations at which the system is tested, wherein the laser emits light at a number of

different wavelengths that correspond to different resonant modes of the laser, and each location of the system has at least one Bragg grating that reflects light at one of the wavelengths of the laser, different locations in the system having different Bragg gratings and/or different combinations of Bragg gratings so that each of the locations will generate a reflection that is characteristic of that location.

According to another aspect, the invention provides a method of monitoring an optical fibre system that includes at least one optical fibre by means of a reflectometry method, the system including a laser for sending light into the system which emits light at a number of different wavelengths corresponding to different resonant modes of the laser, a detection station for receiving light that has been reflected by the system and, at a number of locations in the system, at least one Bragg grating that reflects light at one of the wavelengths of the laser, different locations having different Bragg gratings and/or combinations of Bragg gratings so that each of the locations will generate a reflection that is characteristic of that location, which method comprises sending light into the system by means of the laser, detecting reflected light from the system and analysing the reflected light to obtain information about the system.

In the case of systems that carry traffic, e.g. optical telecommunications systems, the wavelengths reflected by the gratings will normally be different from the traffic wavelength in order to prevent any effect on the traffic.

The present invention has the advantage that it is possible to identify a large number of end users of the network by using only a small number of different wavelengths. The number of end users or other nodes in the system that can be identified will depend on the way the system is arranged. For example, at at least some of the locations, Bragg gratings having different line spacings may be overwritten. In such a case, n different wavelengths could be used to identify 2^n-1 different locations, assuming at least one wavelength must be reflected. Alternatively the precise position of the Bragg gratings within each location could be varied to give spatial

encoding of the gratings if the spatial separation can be resolved. In such a case, for n different wavelengths and p spatial positions n^p different locations can be identified. It is possible to employ spatial encoding in combination with overwriting of different Bragg gratings, in which case $(2^n-1)^p$ different locations can be identified using n different wavelengths and p spatial positions. In such a case the reflection pattern can be considered as a number having a number of digits equal to the number of different spatial positions and a modulo corresponding to the number of different Bragg gratings. It is possible to employ conventional data manipulation methods on the reflected signals. For example, redundancy may be built in to the Bragg combinations for the purpose of error checking and/or error correction, with the result that it may be possible to identify end users even with relatively high levels of noise; start/stop bits may be included and the like. Also other forms of coding, for instance pulse width modulation or pulse position modulation may be used.

The system according to the invention exploits an inherent property of one form of laser, i.e. that a number of different wavelengths are generated, in order to aid analysis of reflectometry results from such systems. This property is generally undesirable in lasers employed in communication systems with the result that such lasers, e.g. Fabry Perot lasers, are relatively inexpensive as compared with those lasers such as distributed feedback lasers that emit light at only a single wavelength. The invention has the advantage that not only is the laser relatively inexpensive, but that only one laser, or only a small number of such lasers need be used. The laser will normally emit light at at least three wavelengths and typically from five to seven different wavelengths in its spectral envelope. In addition, it is conjectured that lasers such as mode-locked lasers could be employed. Such lasers can inherently generate very narrow pulses suitable for OTDR which have a relatively broad wavelength spectrum with a relatively broad mode locked spectrum.

The system may be any system which is to be monitored by means of a reflectometry method. For example, it may be an optical fibre system for monitoring temperature, stress or other parameters, or it may be a communications network, for

example one which includes a plurality of branches between a station end and a plurality of end users.

The system can be monitored by a reflectometry method, either in the time domain (OTDR) or in the frequency domain (OFDR). OFDR may be preferred since it is possible to obtain higher spatial resolution without sacrificing dynamic range. Whichever method is employed the reflection pattern of the system can be recorded for example in a computer memory and reflection patterns subsequently obtained during the monitoring process can be compared with the original reflection pattern stored in the memory and any changes in the reflection patterns identified as possible system faults. In the case of branched networks, the system and method according to the invention has the significant advantage over conventional networks that are monitored by OTDR or OFDR methods in that it is not necessary to ensure that branches of the network are of different lengths (which was necessary in order to be able to resolve the reflections due to different branches in the reflection pattern). According to the present invention, different branches of the network may have substantially the same length so that reflection patterns due to different combinations of gratings overlie one another in the reflection pattern of the network. Means may be provided for analysing the reflected light to ascribe a given location or combination of locations to each combination of reflected light wavelengths. In this case, if one branch is subjected to a fault so that the reflection pattern of one of the grating combinations is attenuated, the relevant reflection pattern will clearly be identified simply by subtracting the reflection pattern of the network from the network reflection pattern stored in memory. In addition, since the majority of reflection patterns will be accounted for, there will only be a small number of possible combinations of bit patterns that overlie each other at any position.

Preferably the network includes further combinations of gratings between the end users and the station end, normally being located at one or more nodes in the network, and especially the network includes a combination of gratings at each node in the network. In such a network, receipt of a reflection pattern corresponding to that

of a given node will indicate continuity of the network up to that node. However, the provision of gratings at the nodes has an additional advantage in that it is possible to compare the intensity of light reflected at one point in the network (be it an end user or a node) with the intensity of light reflected at a second point connected thereto by a fibre link and located nearer to the station end of the network. Such a comparison, together with a knowledge of the length of the fibre link and the expected attenuation of signals at the relevant wavelength, can provide an indication of the quality of the optical fibre link. Thus, for example, if the attenuation of the monitoring signals in the fibre link begins to rise, this can indicate deterioration of that link, for example due to hydrogen or water permeation or due to stress on the optical fibre, and can allow remedial action to be undertaken before the fibre link fails.

Yet a further advantage of the network according to the invention is that if a break occurs at any point in the network where a number of fibres need to be re-spliced, the engineer can conduct an OTDR or OFDR measurement into each end of the broken fibres in order to ascertain which line any given fibre end corresponds to. Such measurement may be conducted non-intrusively, for example, by means of equipment for forming microbending and/or macrobending taps.

The detection station in the system will normally be one that can separate the reflected light into wavelengths corresponding to the grating spacings of the Bragg gratings and detect the presence of reflected light at each wavelength. For example it may comprise one or more splitters at which reflected light is split into a plurality of channels, each channel having a Bragg grating that corresponds to the wavelength of a different resonant mode of the laser, and a plurality of light detectors e.g. p-i-n diodes, each of which detects light reflected by one of the Bragg gratings of the detector station. Alternatively, the detector station may utilise a dispersive element to separate the individual wavelength signals with respect to time to an extent sufficient to enable the detector to resolve the individual wavelength components. Such an element may comprise a chirped Bragg grating (or a number of discrete, spatially separated, Bragg gratings of different grating spacings) or a length of

appropriately chromatically dispersive fibre.

In the spectrum of the laser the peak width for each emitted wavelength is relatively narrow, typically about 0.2nm, and if different locations of the system are at significantly different temperatures there is the possibility that the reflection wavelength of certain Bragg gratings may be shifted and that a required reflection may not occur. This problem may be overcome if one or more Bragg gratings of the system have a non-uniform grating spacing so that it will reflect light of a broader spectrum than a uniform grating. The degree of non-uniformity should be sufficient to accommodate any changes in temperature of the grating but insufficient to reflect light from more than one resonant mode of the laser.

The Bragg gratings in the optical fibre may be formed in a number of ways. For example, the grating may be recorded as a hologram, and an image of the grating subsequently may be formed in the optical fibre by shining ultraviolet light through the hologram. Alternatively, a beam of ultraviolet light may be shone through a mesh having the appropriate grating printed thereon and focused onto the fibre. In yet another method, a line of ultraviolet light may be passed along a portion of the fibre at a defined speed and its intensity may be modulated at a frequency that will give the desired line spacing along the fibre. Whichever method is employed the refractive index of the optical fibre core will vary periodically in accordance with the intended line spacing. Such a fibre will transmit light over a range of wavelengths, but if the light wavelength (in vacuum) λ is related to the line spacing d of the grating by the Bragg formula

$$\lambda = 2 n d$$

where n is the mean refractive index of the fibre, then part of the signal is reflected back by the grating.

Such Bragg gratings may be formed for example as described in European

patent applications Nos. 438759A and 507882A or international application No. WO86/01303.

One form of optical system according to the present invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of part of the optical system according to the invention;

Figure 2 is a view in greater detail of part of the detection station of the system of figure 1;

Figure 3 is a spectrum of the laser employed in the system; and

Figure 4 is a view in greater detail of a location in the system of figure 1 in which light is reflected.

Referring to the accompanying drawings figure 1 shows schematically a simplified passive optical network in which a station end or head end 1 is connected to a number of end users or subscribers 2 to 5 by optical fibres in a tree configuration. As shown, an optical fibre leg 8 extends from the head end 1 to a first node 10 comprising a 1:4 splitter, and one arm 12 of the node 10 extends to a second node 14 comprising a further 1:4 splitter. Each of the arms 16, 18, 20 and 22 of the second node extend to its respective end user 2 to 5.

The network includes an optical reflectometry system for monitoring the network which comprises a laser 24 that sends a series of TDR pulses to a coupler 26 that couples the pulses into the network. The laser is a Fabry Perot laser that has a spectrum as shown in figure 3 comprising eight emission peaks λ_{41} to λ_{48} at wavelengths varying from about 1303nm to about 1311nm. Each peak has a width

of about 0.2nm and is spaced from adjacent peak(s) by about 1nm. In the system the six central peaks of wavelength from about 1304 to about 1310nm are employed for monitoring the network.

Each node 10 and 14 has associated with it a location 24 and 26 comprising a combination of Bragg gratings and each of the end users 2 to 5 has an associated location 32 to 35 each of which comprises another combination of Bragg gratings.

One of the locations 24, 26 or 32 to 35 is shown in greater detail in figure 4 and comprises six positions 51 to 56 in which a Bragg grating may or may not be written. Position 51 always contains a Bragg grating having a grating spacing corresponding to emission peak λ_{42} of the laser 24 while positions 52 to 56 may or may not contain a Bragg grating corresponding to emission peak λ_{43} to λ_{47} respectively, depending on the desired reflection pattern of the location. The gratings may be spatially separated as shown or alternatively they may be overwritten on one another.

The initial pulse from the laser 24 and the reflected signal are sent down line 60 to detection station 61 which comprises six filters f_1 to f_6 and six detectors D_1 to D_6 for example a p-i-n diode that controls an FET amplifier circuit.

The outputs from the detectors are converted to digital signals and are stored in the memory of a suitably programmed microcomputer.

In order to monitor the network by an OTDR method, laser 24 emits a pulse into the network and also into line 60 and the reflected pulse is received by detection station 61 and is stored in the microcomputer memory as a function of time delay from the initial pulse. The detector D_1 records reflections from all the nodes and end users of the system since each end location contains a Bragg grating corresponding to λ_{42}, so that its output corresponds to a conventional OTDR reflectogram. However, each peak in the reflectogram of detector D_1 has an associated combination of peaks

received by detectors D_2 to D_6 corresponding to the presence or absence of gratings at positions 52 to 56. This combination enables each peak of the reflectogram observed by D_1 to be uniquely identified.

Claims:

1. An optical fibre system which includes at least one optical fibre and which is tested at a number of locations by a reflectometry method, the system including a laser for sending light into the system and a detection station for receiving light that has been reflected at the locations at which the system is tested, wherein the laser emits light at a number of different wavelengths that correspond to different resonant modes of the laser, and each location of the system has at least one Bragg grating that reflects light at one of the wavelengths of the laser, different locations in the system having different Bragg gratings and/or different combinations of Bragg gratings so that each of the locations will generate a reflection that is characteristic of that location.

2. A system as claimed in claim 1, wherein the laser emits light at at least three different wavelengths.

3. A system as claimed in claim 2, wherein the laser emits light at from five to seven different wavelengths.

4. A system as claimed in any one of claims 1 to 3, which includes more than one Bragg grating at each location.

5. A system as claimed in claim 4, wherein at at least some of the locations Bragg gratings having different grating spacings are overwritten.

6. A system as claimed in claim 4 or claim 5, wherein at at least some of the locations Bragg gratings are spatially separated.

7. A system as claimed in any one of claims 1 to 6, which is an optical network that includes a plurality of branches between a station end and a plurality of end

users.

8. A system as claimed in any one of claims 1 to 7, wherein the laser is a Fabry Perot laser.

9. A system as claimed in any one of claims 1 to 8, wherein the detection station for reflected light can separate the reflected light into the wavelengths corresponding to the grating spacings of the Bragg gratings and detect the presence of reflected light at each wavelength.

10. A system as claimed in claim 9, wherein the detection station comprises one or more splitters at which reflected light is split into a plurality of channels, each channel having a Bragg grating that corresponds to the wavelength of a different resonant mode of the laser, and a plurality of light detectors, each of which detects light reflected by one of the Bragg gratings of the detector station.

11. A system as claimed in any one of claims 1 to 10, wherein one or more of the Bragg gratings in the system has a non-uniform grating spacing, the degree of non-uniformity being sufficient to accommodate any changes in temperature of the grating but insufficient to reflect light from more than one resonant mode of the laser.

12. A system as claimed in any one of claims 1 to 11, which includes means for analysing the reflected light to ascribe a given location or combination of locations to each combination of reflected light wavelengths.

13. A method of monitoring an optical fibre system that includes at least one optical fibre by means of a reflectometry method, the system including a laser for sending light into the system which emits light at a number of different wavelengths corresponding to different resonant modes of the laser, a detection station for receiving light that has been reflected by the system and, at a number of locations in

the system, at least one Bragg grating that reflects light at one of the wavelengths of the laser, different locations having different Bragg gratings and/or combinations of Bragg gratings so that each of the locations will generate a reflection that is characteristic of that location, which method comprises sending light into the system by means of the laser, detecting reflected light from the system and analysing the reflected light to obtain information about the system.

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Fig.1.

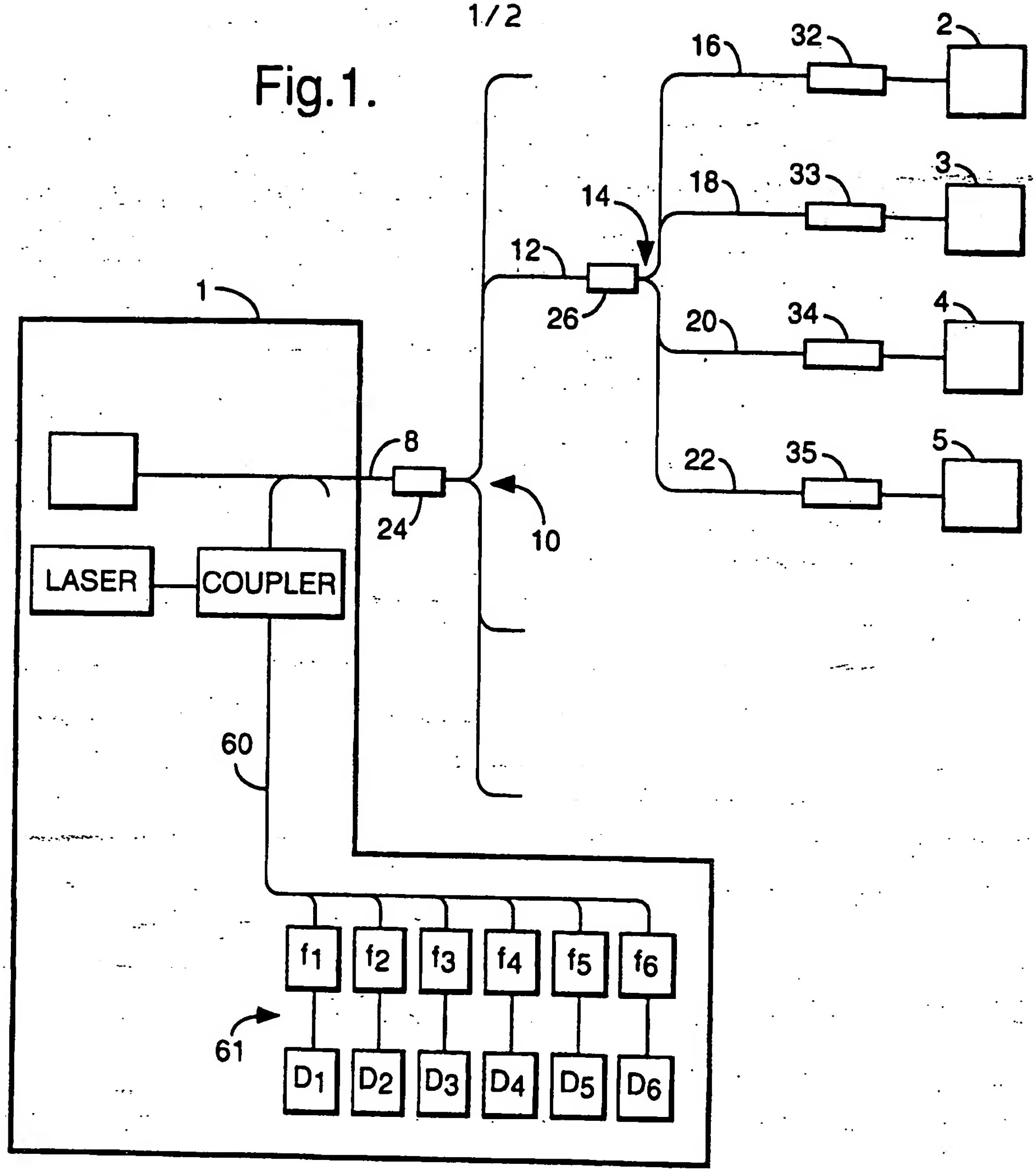


Fig.2.

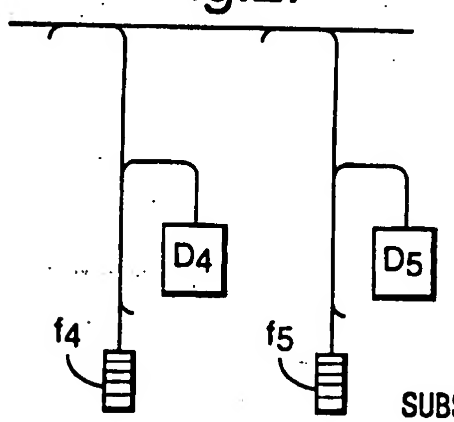


Fig.4.

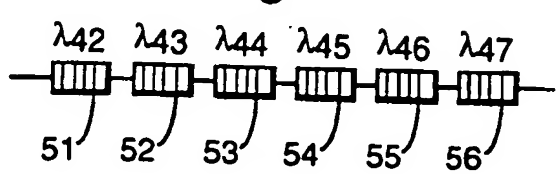
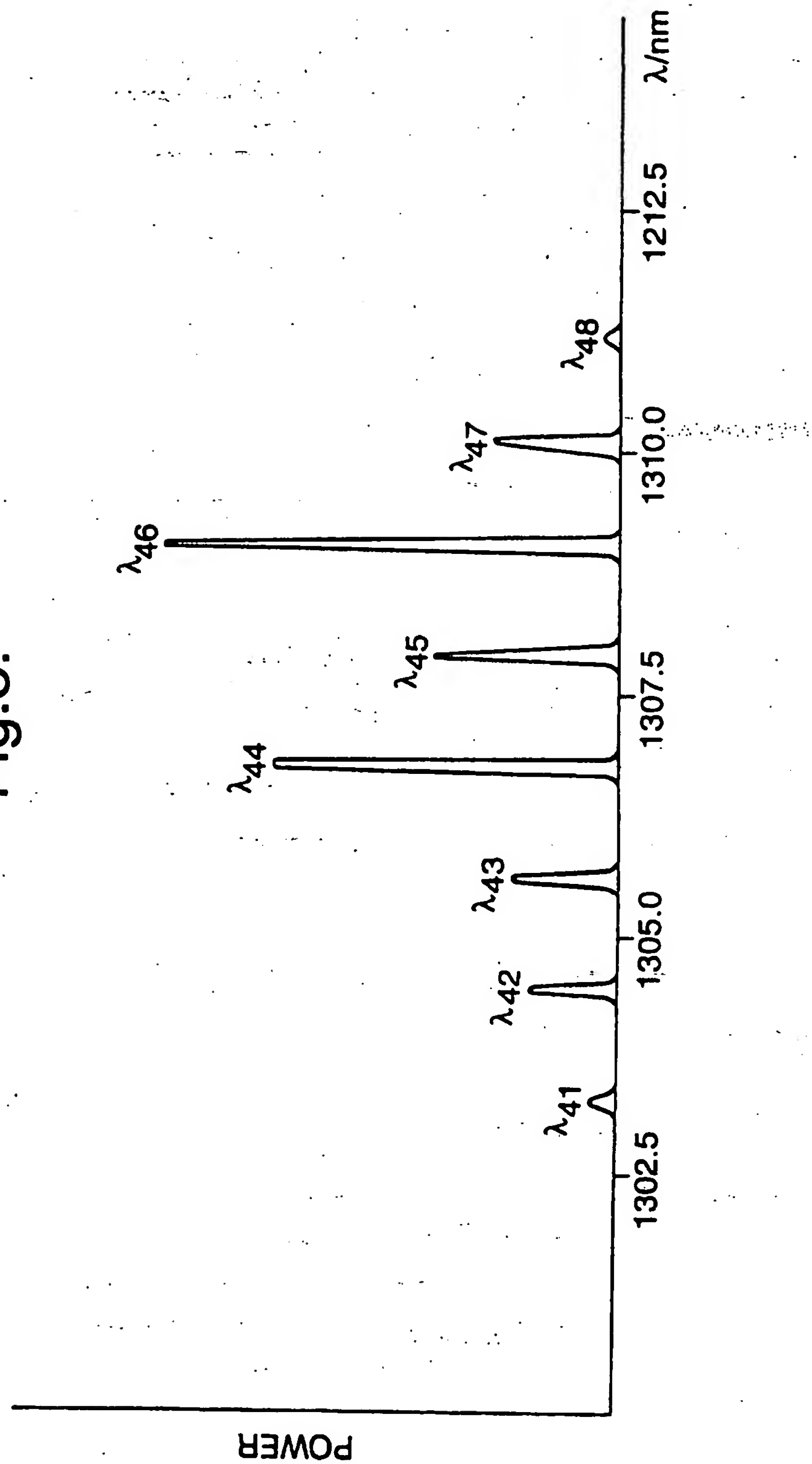


Fig.3.


λ/nm
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1310.0
1307.5
1305.0
1302.5
λ_{48}
λ_{47}
λ_{46}
λ_{45}
λ_{44}
λ_{43}
λ_{42}
λ_{41}
POWER

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 96/01771

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04B10/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04B G01M H04J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP,A,0 592 690 (SUMITOMO ELECTRIC INDUSTRIES) 20 April 1994 see column 9, line 51 - column 12, line 31 see column 15, line 33 - column 16, line 11 see figures 8-10,12,16 ---	1-4,6-8, 12,13
Y	EP,A,0 452 895 (CANON) 23 October 1991 see column 4, line 49 - column 5, line 20 ---	1-4,6-8, 12,13
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1

Date of the actual completion of the international search	Date of mailing of the international search report
5 November 1996	29. 11. 96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Williams, M.I.

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International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	OPTICS LETTERS, vol. 14, no. 15, 1 August 1989, WASHINGTON US, pages 823-825, XP000033795 MELTZ ET AL: "Formation of Bragg gratings in optical fibers by a transverse holographic method" see abstract -----	1,13

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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A-592690	20-04-94	JP-A-	5307118	19-11-93
		JP-A-	5307119	19-11-93
		JP-A-	5307120	19-11-93
		JP-A-	5307121	19-11-93
		JP-A-	5307122	19-11-93
		JP-A-	5313020	26-11-93
		JP-A-	5313021	26-11-93
		AU-A-	4271393	29-11-93
		NO-A-	934917	24-02-94
		US-A-	5506674	09-04-96
		CA-A-	2112692	02-11-93
		CN-A-	1082717	23-02-94
		WO-A-	9322647	11-11-93
EP-A-452895	23-10-91	JP-A-	4000932	06-01-92
		JP-A-	4068930	04-03-92
		DE-D-	69120582	08-08-96
		US-A-	5369516	29-11-94